PROC. ENTOMOL. SOC. WASH.
92(4), 1990, pp. 802–807

SEASONAL ABUNDANCE AND HABITS OF THE BOXELDER BUG, *BOISEA TRIVITTATA* (SAY), IN AN URBAN ENVIRONMENT

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Abstract.—*Boisea trivittata* (Say) (Family Rhopalidae), the boxelder bug, is a common household pest in the United States. Large aggregations of adults and nymphs of this plant bug can form on the primary host tree, *Acer negundo* L., and other maples, or on buildings in urban environments. Overwintering boxelder bugs often seek harborage in protected areas around houses. The pest status of this insect is based primarily on the presence of large aggregations in the spring and the fall, and movement indoors where their excrement can stain fabric. Information on the biology and influence of substrate temperature on its activity was obtained from studies of laboratory and field populations in urban environments in Virginia. Adult boxelder bugs were present twice during the calendar year 1988. Overwintering adults were active from April to June, and first generation adults were present from August to October. In laboratory colonies, the number of days between mating and egg laying was 1–5, the mean number of eggs per mass was 9.5 (laboratory) and 9.9 (field), and the mean incubation period was 10 days. The range of survival was 1–22 days for males, and 1–20 days for females. Adult and nymphal boxelder bugs responded to temperature differences by aggregating on the warmest substrates available. Thoracic temperatures of adult boxelder bugs were significantly higher than ambient air, and the differences between substrate and thoracic temperatures ranged from 3.4 to 7.0°C.

Key Words: biology, mating, feeding, thoracic temperatures

Boisea trivittata (Say), the boxelder bug, is a scentless plant bug in the family Rhopalidae. It is a minor pest of some fruit crops, and a widely distributed, common household pest in the United States (Wheeler 1982). Boxelder bugs are usually found near their primary host, the boxelder tree, *Acer negundo* L. However, feeding is not restricted to this species of maple. *B. trivittata* has been found feeding on other trees, including *A. saccharinum* (L.), *Quercus* spp., and *Ailanthus altissima* (Mill.) (McDaniel 1933, Smith and Shepherd 1937, Wheeler 1982).

Large aggregations of adults and nymphs can form on houses during spring and fall and cause concern among homeowners. Overwintering boxelder bugs move into houses through open windows and doors, and cracks and crevices around windows, doors, and eaves in the fall. When indoors, adults can stain fabric with their excrement (Davis and Joos 1982). Taub (1970) reported severe asthmatic reactions during fall migrations of boxelder bugs into homes. The pest status of *B. trivittata* was reported by Swenk (1929), Ascerno (1981), and Pinkston (1988).

Early studies focused on the geographic distribution, taxonomy, morphology, and development of *B. trivittata* (Howard 1898, Smith and Shepherd 1937, Knowlton 1944, Tinker 1952). The objectives of the research reported here were to elucidate seasonal abundance, life cycle data, microhabitat temperature preferences, and boxelder bug activity in response to temperature in an urban environment.

Materials and Methods

Seasonal abundance.—Field populations of boxelder bugs were sampled from April to December, 1988, at three houses, three apartment buildings, and one utility building in Blacksburg, Virginia. These structures were inspected three times per month for boxelder bugs. The base of the foundation walls on the south and west exposures were partitioned into one meter squares with spray paint. The wall, ground, and vegetation located within sample squares were examined, and all adult and nymphal boxelder bugs within the square were recorded. The total number of insects in each square were summed over all squares per site.

At one apartment building (site F) three boxelder trees located approximately 10 m from the building were sampled for adults and nymphs with a plastic container and hand brush. The opening of the container contained a funnel and was held at the base of the tree. Boxelder bugs were lightly brushed from the bark into the container. After sampling, the containers were returned to the laboratory and the bugs were sexed, counted, and later returned to the trees and released.

The sex ratio of overwintering adults was determined from boxelder bug populations at four building sites. Four samples were taken each week for a five-week period from September and December, 1988. Samples of soil and leaf litter were removed from the southwest exposure of the building and taken to the laboratory where boxelder bugs were removed, sexed and counted.

Biological information.—Laboratory colonies were initiated with adults obtained from field populations in Blacksburg, Virginia in spring, 1988. Rearing methods were similar to those reported by Smith and Shepherd (1937). Thirty-eight females and 30 males were maintained in the laboratory for life history studies. Pairs were maintained in 3.8 liter glass jars and provided with fresh boxelder leaves and water. Water bottles and leaf material were replaced daily. Mortality was recorded daily and dead individuals were removed and replaced. Egg masses were transferred from jars to petri dishes (100 × 15 mm). After hatch, first instar nymphs were transferred to plastic cups (9.5 × 5.5 × 8 cm) and supplied with small boxelder leaves. Cheesecloth was used to retain nymphs and adults in the containers. Rearing conditions were 20–22°C, 58–62% RH, and 12:12 h photoperiod.

Temperature selection.—Visual observations were conducted on the activity of adults and nymphs in response to sunlight. The movement of second-generation boxelder bugs on the trunks of three boxelder trees was recorded several times during the day in September.

Temperatures from substrates on three houses (A, B, C) in Blacksburg were recorded from October 21 to November 15. The substrates included white-painted, aluminum siding, concrete, brick, and colored canvas. The houses were selected on the basis of existing infestations of boxelder bugs. An insulated thermistor probe attached to a micrologger (Campbell CR21 Micrologger) was used to measure temperatures in the microhabitats sampled. The styrofoam-insulated (2 layers) thermistor probe was attached to the substrates for 6 min. Ambient air temperature was measured by placing the probe in the air and recording for 15 min. The micrologger was programmed to record maximum, minimum, and average temperatures every 3 min. Records were maintained for the time, Julian day, and microhabitat where the probe recorded temperature. Data were loaded onto a cassette recorder and transferred to an IBM mainframe computer program for analysis.

Internal thoracic temperatures of 156 adult boxelder bugs at sites A, B, and C were taken with a 0.03 cm chrome-alumel (Omega) thermocouple insulated with Tygon tubing. The thorax was held with rubber gloves and forceps, and the thermocouple inserted posteroventrally between the second and third coxae. Because of the large size of the thermocouple, a time-constant of fifteen seconds was used to record temperatures. The specific microhabitat where the insects were found was also recorded.

Data were analyzed using the SAS-GLM procedures (SAS Institute Inc. 1985); the Student-Newman-Keuls Range test was used to separate means.

Results and Discussion

Seasonal abundance.—Adult boxelder bugs are present twice during the calendar year. The surviving overwintering adults are active in the spring. The first generation adults produced that year are present in late summer and fall, and form the overwintering population. Wollerman (1965) reported two generations of the boxelder bug in the South and one in the North. Smith and Shepherd (1937) reported two generations of boxelder bugs in Kansas.

Overwintering generation.—Adults were found primarily in leaf litter, on bark around *A. negundo* and *A. saccharinum* trees, and in mulch on southern exposures of residences. During April, some adults observed at overwintering sites became active. Mating activity was observed from March 11 to June 15 on the outside walls of residences, at the base of *A. negundo* and *A. saccharinum* trees, and on low vegetation around residences.

Females laid eggs predominantly on the surface of buildings in April and May. Egg deposition sites appeared to shift to low vegetation from June to August. First-generation eggs were first observed on April 14, and nymphs appeared during the second week of May. Egg deposition by first-generation adults ceased the last week in June. The mean number of eggs per mass counted in the field was 9.9 ($n = 123.0$; $SD = 4.3$; range = 2–21). The mean percentage egg hatch was 84.4%. The number of nymphs increased during the last week of June, and numbers peaked during the first week of July. This increase was followed by a low number of nymphs observed from the end of July through August. The number of adult boxelder bugs at all sites remained low until mid-June. There was a gradual increase in the number of adults observed from mid-June to the end of July.

Adults were observed mating and feeding on female boxelder trees in mid-July. No mating was observed on low vegetation during July or August. A general decrease in the adult population was observed during August. Tinker (1951) reported adults feeding and mating on female boxelder trees in August and September. The results from this study indicate that during late summer first-generation adults move from buildings to host trees and ground sites.

First generation.—An increase in the number of first-generation nymphs occurred during late August to September (Fig. 2). A decline in the nymphal population occurred in October, and only small numbers of nymphs were observed from October through December. A decreased number of nymphs was followed by an increase in the number of adults observed on the surfaces of buildings in mid-October. Movement of adults to buildings at all of the sites occurred at this time. Tinker (1951) reported an abundance of adults in August and September on female boxelder trees in Minnesota, which coincided with the development and maturity of the *A. negundo* ovules. Smith and Shepherd (1937) reported that boxelder bugs sought shelter in early October, and movement out of hibernation began in late March in Kansas. Time of dispersal to search for feeding or overwintering sites may vary with geographic location (Wollerman 1965).

The sex ratio of second-generation adults was approximately 1:1. The ratio reported here contradicts the ratio (2:1, female : male) reported by Smith and Shepherd (1937). The method of sampling adults could account for the disparity in the ratio reported by Smith and Shepherd (1937) and that reported here.

Life cycle

Laboratory colony.—Mating did not occur immediately after adults were paired in rearing jars. Mating behavior was not observed until several days after males and females were placed in the jars. When two males were placed with one female there was often aggression between the males when both attempted to copulate with the female. Several observations were made of males that mounted females on the posterodorsal side and extended their beak between the elytra of the female. Of the 38 females observed, 16 did not lay eggs. The number of days between mating and egg laying ranged from 1 to 5 (n = 22).

In the laboratory the mean number of eggs per mass was 9.5 (n = 33, SD = 7.7). Smith and Shepherd (1937) reported an average of 10 eggs per mass. The mean incubation period calculated from all eggs for all batches was 10 days. The incubation period was 12 and 13 days for eggs from females that laid 2 and 3 batches, respectively. Smith and Shepherd (1937) reported a range between 11 and 19 days and a mean of 13 days for boxelder bug oviposition period. Egg batches were laid in various size groups. Newly laid eggs were light orange, but turned dark red before hatching. Forty-one percent of the females laid no eggs, 43.6% laid 1 batch, 10.3% laid 2 batches, and 5.1% laid 3 egg batches.

The mean survival of adults in the laboratory was 7.6 days (n = 37; SE = 5.6) for the females and 8.8 days for males (n = 29; SE = 6.27). The range of survival was 1–22 days for males and 1–20 days for females. The average number of days death occurred after eggs were laid was 4.3 days.

Microhabitat temperature selection

Substrates.—Observations of second-generation adults and nymphs on three trees indicated that they oriented primarily toward the side of the trees that received the most sunlight. In the morning a large number of bugs gathered on the eastern-exposed portion of the trunk, and in late afternoon more boxelder bugs were seen on the western exposure. At approximately 9:00 am, an increase in adult and nymphal activity was observed, including movement to the ground at the base of the trees. They may have responded to a change in the incident angle of the sun and temperature. Tinker (1951) reported a preference for sunny exposures of *A. negundo,* but aggregations of bugs dispersed when the area became shaded.

The mean temperatures recorded on southern-exposed substrates of three houses (A–C) are shown in Table 1. The number of boxelder bugs was greatest on substrates that had higher temperatures. At house A the mean temperature (26.5°C) recorded on the white-painted aluminum siding was not significantly different ($P > 0.05$) from the mean temperature (24.3°C) recorded at the concrete foundation. Although there was only a 2.2°C difference in temperatures recorded from the two substrates, there were 113 boxelder bugs on the siding, and 23 boxelder bugs on the concrete foundation.

At house B a mean temperature of 25.2°C was recorded on a window shutter, and this temperature was significantly different ($P < 0.001$) from the 17.9°C recorded behind a rain gutter on that house. Apparently, boxelder bugs at this site responded to the 7.3°C temperature difference by aggregating on the warmer substrate (240 on the window shutter vs. 8 at the rain gutter). Of the approximately 500 boxelder bugs collected at house C, 56 boxelder bugs were recorded on the cement foundation, which had a temperature of 17.1°C. However, 240 boxelder bugs were collected from a piece of blue canvas

Table 1. Microhabitat mean temperatures for boxelder bugs at three sites.

Site	Microhabitat	Temp (C)*	No. Bugs
A	white aluminum siding	26.5a	113
	white alum. siding (east)	15.4b	10
	white alum. siding (north)	10.9c	0
	white alum. siding (west)	27.4a	27
	concrete foundation	24.3a	23
B	window shutter	25.2a	240
	brick	24.7a	140
	rain gutter	17.9b	8
C	blue canvas	24.9a	240
	white aluminum siding	20.2b	121
	concrete	17.1b	56

* Range of 2–5 separate temperature recordings.
Means in each column followed by the same letter are not significantly different (Student-Newman-Keuls multiple range test; $P > 0.05$).

(24.9°C) on the house. Tinker (1952) reported that as little as a 1.0°C to 3.3°C difference between substrates resulted in boxelder bug aggregations on surfaces with the higher temperature.

Insect.—Boxelder bug thoracic temperatures were significantly higher than the ambient temperature; the differences ranged from 3.2 to 3.5°C at three locations ($P < 0.001$) (Table 2). The substrate surface temperatures were always significantly greater than the ambient and thoracic temperatures in the four locations sampled ($P < 0.001$). Differences between substrates and thoracic temperatures ranged between 3.4 and 7.0. The thoracic temperatures may more closely match the temperature of the air immediately above the substrate. Solar radiation heats the boundary layer of air above sunlighted substrates. The temperature differences between substrates, boundary layer air, and ambient may be several degrees (Heath and Wilkin 1970). Heath and Wilkin (1970) reported the thoracic temperature of a desert cicada to be closer to the temperature of the boundary layer air than to that of the substrate or ambient air.

Conclusions

The boxelder bug is a unique pest in the urban environment. Unlike a year-round indoor pest, such as the German cockroach, the boxelder bug is a pest only during spring and fall, but affects urban residents both indoors and outdoors. The apparent preference of the adults and nymphs for warm or heat-retentive surfaces, and the large populations twice each year make this insect an important urban pest. Its pest status is based on the numbers found aggregating in

Table 2. Mean comparisons of thoracic, substrate and ambient air temperatures of boxelder bugs at four locations.

Subject	Temperatures (n) and Locations			
	A	B	C	D
Substrate	28.7a (38)	28.5a (6)	20.3a (11)	20.8a (8)
Thorax	24.9b (8)	21.5b (27)	16.9b (42)	19.8a (17)
Ambient air	21.4c (14)	21.9b (20)	13.7c (10)	16.3b (17)

Means in each column followed by the same letter are not significantly different (Student-Newman-Keuls multiple range test; $P > 0.05$).

and around houses, and its pest importance is indicated by the amount of money urban residents spend on control (Yoder and Robinson 1988).

Nonchemical control strategies for this insect are limited. Smith and Shepherd (1937) reported that no parasites emerged from 452 eggs they observed during rearing. Smith and Shepherd (1937) reported parasitic flagellates in the intestinal tract of *B. trivittata*, but did not appear to cause mortality. Removal of the host tree may be effective (Davis and Joos 1982), and sealing crevices in structures may prevent boxelder bugs from moving indoors. However, Smith and Shepherd (1937) and Wheeler (1982) reported that *B. trivittata* can feed on a variety of ornamental trees and plants. Chemical control of this insect presents several problems. Because this insect is a problem to homeowners primarily during spring and fall, chemical controls are usually initiated after large numbers of bugs aggregate around houses. Photodegradation and volatilization of commonly used insecticides can occur because they are applied to sun-exposed and heat-retaining surfaces. These surfaces are attractive to the insects, but limit insecticide effectiveness. It would be more effective to time and direct chemical applications to the eggs and early instars of the first generation.

Acknowledgments

We thank D. Mullins and R. Fell, VPI&SU Entomology Department, for their suggestions and help with the temperature studies. A. G. Wheeler, Jr., Pennsylvania Department of Agriculture, reviewed and improved the manuscript.

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